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Cosmic Photoshoot to ImPress

DAY 2: Astronomy at Different Wavelengths

You have now created your own unique version of an iconic *Hubble Space Telescope* image.

Our example from Day 1 in Figure 4 shows the Pillars of Creation in visible light, capturing the multi-colored glow of the gas clouds in stark contrast to the dark cosmic dust. The dust and gas comprising this stellar nursery is seared by the intense radiation from young stars, with their strong winds gradually eroding the pillars. With these high resolution Hubble Space Telescope images comes better contrast and a clearer view for astronomers to study how the structure of the pillars is changing over time.

In 2015, the Hubble Space Telescope revisited the Eagle Nebula's Pillars of Creation, now imaging this iconic astronomical object in infrared light. At these longer wavelengths, light can pierce through the obscuring dust and gas cocoons to reveal a different view of the pillars.

Today, we will explore astronomy at different wavelengths, heat press your tote bag, and end with a showcase of your final products and the fun facts you learned.

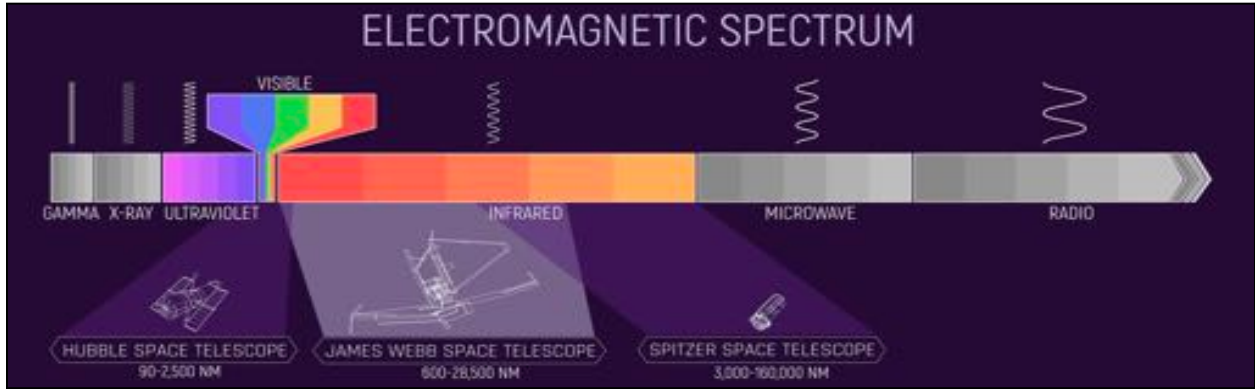
Comparing the Ultraviolet/Optical and Infrared Views.

STEP 1: Load the Images. Follow Steps 3 through 7 from Day 1 Worksheet to make two RGB frames: (1) the same optical filters listed above (in **0-EXAMPLE/Optical**), and (2) a new RGB frame using the F110W and F160W near-infrared filters (in **0-EXAMPLE/Infrared**). For the second infrared image, only 2 files are available, so **load one of these filters twice**, as either the blue/green or green/red. Adjust the settings of the image until you have an infrared color image you are happy with.

STEP 2: Align the Images. Once you have two RGB frames loaded, align the frames so that you can directly compare them. Select the RGB frame with the zoom version you like and go to **Frame→Match→Frame →WCS**, where WCS stands for World Coordinate System. You just told the software to match the images based on their world coordinate systems, where they should now be perfectly astrometrically aligned.

STEP 3: Blink, Blink, Blink. Flip between the two RGB frames (optical and infrared) using your tab key. Holding Shift-Tab blinks in the reverse direction. Take a few moments to look at the images and compare how they are similar and different.

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[1] **Question:** Compare the different astronomical objects that can be seen in the optical and infrared views of the Pillars of Creation. What is similar? What is different? Are there any new objects that can be seen at infrared wavelengths?

[2] **Question:** The *Hubble Space Telescope* is only sensitive out to near-infrared wavelengths of about $1.6\mu\text{m}$, whereas NASA's new flagship mission the *James Webb Space Telescope* is sensitive into the mid-infrared (out to $28\mu\text{m}$). How do you think the Pillars of Creation would look with the *James Webb Space Telescope* at these even longer wavelengths?

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Distances to Astronomical Objects. Open up google and search for the distance to your object in “Astronomical Units”. First google “Distance to _____”. Note the distance AND the units.

[3] **Question:** What is the distance to your object? What are the units?

Now use google to convert to a common unit of Astronomical Units, or AU, which is units of the Earth-Sun distance. For example, Earth is 1 AU from the Sun.

[4] **Question:** What is the distance to your object in AU?

Interactive Distance Ranking Activity. Note (1) what your object is (planet, planetary nebula, galaxy, etc), and (2) the distance to your object. Sort among yourselves to rank the distance of your object from nearest to the Earth to the furthest.



Cosmic Photoshoot Showcase. Once all tote bags are done, please review your fun facts as you will teach the rest of us about your astronomical object.



Who Really Uses This? *Astronomers use all manners of data analysis tools and languages. The process you went through with SAOImageDS9 software was abbreviated (details were skipped), but the steps you took are the same steps that professionals take when analyzing their data. Many professional and amateur astronomers have spent endless hours in front of a computer analyzing the information encapsulated in the very same images you used today.*

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If there is time: Astrophotography This workshop has introduced some information related to astrophotography. To take a good astrophotograph, you need the right exposure time and the right focus. After that, you need image processing.

Most celestial objects are dim. Taking a single very long exposure will make the object brighter on your film (CCD chip), but could also cause problems, including: blurriness because whatever you were using to track your object didn't track perfectly; blurriness because a cloud got in the way; blurriness because your neighbor walked over to offer you pizza and kicked your platform; bright spots on the image because your camera was hit by a cosmic ray (it happens all the time); over-exposure due to the light from a nearby bright star; a streak from someone's headlights reflected into your telescope... if you spent half an hour on a single image, any of these are upsetting.

From both a professional and amateur standpoint, the solution is to take a series of short photographs and then "stack" them: put them together using a digital processing program to obtain a single image which is much brighter and more detailed than any individual image in the stack.

There are additional image processing tasks that are performed to compensate for the limitations of the detector. Then, there are the more subtle points of image processing. For example, how much should you re-balance the color of the bands on Jupiter? Are you enhancing a planetary feature, or creating a "trick" photograph?

Long-time sports photographer and astrophotographer Jerry Lodriguss wrote an essay on "The Ethics of Digital Manipulation" by J. Lodriguss Catching the Light blog:

<https://www.astropix.com/html/processing/ethics.html>

In the end, if you pursue astrophotography, you must make your own decisions about what is appropriate and why. This essay will give you a starting point for your own ruminations.